UNITED STATES DISTRICT COURT

NORTHERN DISTRICT OF CALIFORNIA, SAN FRANCISCO DIVISION

WAYMO LLC, Plaintiff, vs. UBER TECHNOLOGIES, INC.; OTTOMOTTO LLC; OTTO TRUCKING LLC, Defendants.	CASE NO. 3:17-cv-00939 **DECLARATION OF DR. ANDREW WOLFE, PH.D. CONCERNING CLAIM CONSTRUCTION OF U.S. PATENT NO. 9,368,936**

I. INTRODUCTION

1. I, Andrew Wolfe, have been asked by counsel for Waymo LLC ("Waymo") to provide opinions concerning the construction of certain claim terms in U.S. Patent No. 9,368,936 (the "'936 Patent"). The analysis and opinions contained in this declaration are based on the information currently available to me. I understand that the Defendants Uber Technologies, Inc. ("Uber"), Ottomotto LLC ("Ottomotto"), and Otto Trucking, LLC ("Otto Trucking") may provide a responsive claim construction brief and expert opinion. I reserve the right to respond to those materials if they present new arguments or information not previously available.

2. If I am called to testify as an expert witness, I expect to give testimony concerning my qualifications and experience, the technical subject matter of the '936 Patent, the level of ordinary skill in the art, and the proper construction of the disputed claim terms from the '936 Patent.

3. I am being compensated for my work on this matter at my current consulting rate of $550 per hour. I am separately reimbursed for expenses. As an independent consultant, I am being compensated solely for my time spent and my compensation is not contingent on the content of my opinions or the outcome of this action.

II. QUALIFICATIONS AND EXPERIENCE

4. My qualifications for presenting the opinions in this declaration are set forth in my curriculum vitae, a copy of which is attached as Appendix A to this report.

5. I have more than 30 years of experience as a computer architect, computer system designer, electronics designer, educator, and executive in the electronics industry. I teach the undergraduate Mechatronics courses at Santa Clara University in the Departments of Electrical Engineering, Mechanical Engineering, and Computer Engineering.

6. In 1985, I earned a B.S.E.E. degree in Electrical Engineering and Computer Science from The Johns Hopkins University. In 1987, I received an M.S. degree in Electrical and Computer Engineering from Carnegie Mellon University. In 1992, I received a Ph.D. in Computer Engineering from Carnegie Mellon University. My doctoral dissertation proposed a new approach for the architecture of a computer processor.

7. I initially developed experience in light-triggering systems when I designed photoflash circuits. I worked as both an amateur and professional photographer while I was studying Electrical Engineering. I studied charging and firing circuits and build several for my own use. I later developed numerous Light-Emitting Diode triggering circuits for use in both consumer and industrial systems including touchscreen systems and remote controls.

8. In 1983, I began designing capacitive touch sensors, microprocessor-based computer systems, and I/O (input/output) cards for personal computers as a senior design engineer for Touch Technology, Inc. During the course of my design projects with Touch Technology, I designed I/O cards for PC-compatible computer systems, including the IBM PC-AT, to interface with interactive touch-based computer terminals that I designed for use in public information systems. I continued designing and developing related technology as a consultant to the Carroll Touch division of AMP, Inc., where in 1986 I designed one of the first custom touch-screen integrated circuits. I designed the pen-based touch input system for the Linus WriteTop, which I consider to be the first commercial tablet computer.

9. From 1986 through 1987, I designed and built a high-performance computer system as a student at Carnegie Mellon University. From 1986 through early 1988, I also developed the curriculum, and supervised the teaching laboratory, for processor design courses.

10. In the latter part of 1989, I worked as a senior design engineer for ESL-TRW Advanced Technology Division. While at ESL-TRW, I designed and built a bus interface and memory controller for a workstation-based computer system, and also worked on the design of a multiprocessor system.

11. At the end of 1989, I (along with some partners) formed The Graphics Technology Company. Over the next seven years, as an officer and a consultant for The Graphics Technology Company, I managed the company's engineering development activities and personally developed dozens of touch screen sensors, controllers, and interactive touch-based computer systems.

12. I have consulted, formally and informally, for a number of fabless semiconductor companies. In particular, I have served on the technical advisory boards for two processor design companies: BOPS, Inc., where I chaired the board, and Siroyan Ltd., where I served in a similar

role for three networking chip companies—Intellon, Inc., Comsilica, Inc, and Entridia, Inc.—and one 3D game accelerator company, Ageia, Inc.

13. I have also served as a technology advisor to Motorola and to several venture capital funds in the U.S. and Europe. Currently, I am a director of Turtle Beach Corporation, providing guidance in its development of premium audio peripheral devices for a variety of commercial electronic products.

14. From 1991 through 1997, I served on the Faculty of Princeton University as an Assistant Professor of Electrical Engineering. At Princeton, I taught undergraduate and graduate-level courses in Computer Architecture, Advanced Computer Architecture, Display Technology, and Microprocessor Systems, and conducted sponsored research in the area of computer systems and related topics. I was also a principal investigator for DOD research in video technology and a principal investigator for the New Jersey Center for Multimedia Research. From 1999 through 2002, I taught the Computer Architecture course to both undergraduate and graduate students at Stanford University multiple times as a Consulting Professor. At Princeton, I received several teaching awards, both from students and from the School of Engineering. I have also taught advanced microprocessor architecture to industry professionals in IEEE and ACM sponsored seminars.

15. I am currently a lecturer at Santa Clara University, periodically teaching courses on Computer Organization and Architecture and Mechatronics. My mechatronics class is an interdisciplinary course combining aspects of electrical, mechanical, and computer engineering. The course involves a laboratory requirement where students develop different machines using sensors, actuators, electronics, and computer software to perform specified tasks. In a recent lab, my students built robots equipped with machine vision, motion sensors, and ranging sensors to navigate a small golf course. Among other topics, I teach students how to drive light emitters, to build light-sensing circuits, and to use these together to make measurements.

16. From 1997 through 2002, I held a variety of executive positions at a publicly-held fabless semiconductor company originally called S3, Inc. and later called Sonicblue Inc. I held the positions of Chief Technology Officer, Vice President of Systems Integration Products, Senior Vice

President of Business Development, and Director of Technology, among others. At the time I joined S3, the company supplied graphics accelerators for more than 50% of the PCs sold in the United States. At S3, I supervised the design of several PC graphics chips. I also worked on the development of PDAs and Touch-based tablet computers.

17. I have published more than 50 peer-reviewed papers in computer architecture and computer systems and IC design. I also have chaired IEEE and ACM conferences in microarchitecture and integrated circuit design and served as an associate editor for IEEE and ACM journals. I serve on the IEEE Computer Society Awards committee. I am a Senior Member of IEEE and a Member of ACM. I am a named inventor on at least 53 U.S. patents and 28 foreign patents.

18. In 2002, I was the invited keynote speaker at the ACM/IEEE International Symposium on Microarchitecture and at the International Conference on Multimedia. From 1990 through 2005, I was also an invited speaker on various aspects of technology and the personal computer ("PC") industry at numerous industry events including the Intel Developer's Forum, Microsoft Windows Hardware Engineering Conference, Microprocessor Forum, Embedded Systems Conference, Comdex, and Consumer Electronics Show, as well as at the Harvard Business School and the University of Illinois Law School. I have been interviewed on subjects related to computer graphics and video technology and the electronics industry by publications such as the Wall Street Journal, New York Times, Los Angeles Times, Time, Newsweek, Forbes, and Fortune as well as CNN, NPR, and the BBC. I have also spoken at dozens of universities including Massachusetts Institute of Technology, Stanford, University of Texas, Carnegie Mellon, University of California at Los Angeles, University of Michigan, Rice, and Duke.

III. MATERIALS CONSIDERED

19. I have considered the following materials in evaluating the disputed claim terms and preparing this declaration:

- The '936 Patent, its provisional application and prosecution history, and prior art cited during the prosecution history;
- The parties' Patent Local Rule 4-2 disclosures of intrinsic and extrinsic evidence and materials cited in the disclosures, including dictionary definitions;

- Technical literature cited in this declaration to help explain the technical concepts underlying the ’936 Patent and disputed claim terms; and
- The deposition transcript of Samuel Lenius.

IV. LEGAL STANDARDS

A. Claim Construction

20. I understand that the words of a claim are generally given their ordinary and customary meaning. I understand the ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention. I understand the person of ordinary skill in the art is deemed to read the claim term not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the specification.

21. I understand claim construction focuses on the intrinsic evidence, which consists of the claims themselves, the specification, and the prosecution history. I understand the claims can provide helpful context for how the claim term is used. I understand the specification is highly relevant to the claim construction analysis and usually dispositive concerning the meaning of a claim term. I also understand, however, that the particular examples or embodiments discussed in the specification are not to be read into the claims as limitations. I understand that the prosecution history can provide information about how the United States Patent & Trademark Office (“USPTO”) patent examiner and the patent applicant understood the claim language.

22. I understand that extrinsic evidence may also be considered when determining the meaning of a claim. I understand there are different sources of extrinsic evidence, including dictionaries, inventor testimony, expert testimony, and learned treatises. I understand that intrinsic evidence is generally favored over extrinsic evidence, and that extrinsic evidence may not be used to contradict the meaning of the claim when read light of the intrinsic evidence. I understand there are two exceptions to the general rule that claims are given their ordinary and customary meaning as understood by a person of ordinary skill in the art when read in the context of the specification and prosecution history, referred to as lexicography and disavowal. I understand that to act as its own lexicographer, a patentee must clearly set forth a definition of the claim term that is different

than its plain and ordinary meaning, and clearly express an intent to redefine the term. I understand that disavowal requires a clear and unmistakable disclaimer of claim scope, such as the specification or prosecution history making clear that the invention does not include a particular feature, or that it is limited to a particular embodiment of the invention.

B. The Definiteness Requirement

23. I understand that patent claims must be definite, which means that they must particularly point out and distinctly claim the subject matter that the applicant regards as the invention. I understand that the standard for definiteness is whether the patent claims, viewed in light of the specification and prosecution history, inform those skilled in the art about the scope of the invention with reasonable certainty. I understand that terms of degree do not automatically render a claim indefinite, and that the definiteness standard does not require absolute or mathematical precision. Instead, I understand that the definiteness requirement will be met if the specification and prosecution history provide objective boundaries for those of skill in the art.

V. THE ’936 PATENT

A. Background and Summary

24. The ’936 Patent is titled, “Laser Diode Firing System” and names Samuel W. Lenius and Pierre-yves Droz as inventors. The patent was filed on December 18, 2013, and claims priority to U.S. Provisional Application No. 61/884,762, filed September 30, 2013. The patent issued on June 14, 2016.

25. The ’936 Patent discloses an improved firing system for laser diodes that drive a LiDAR system. The laser diodes are used to generate pulses of light that are transmitted through the optical components of the LiDAR system (*e.g.*, lenses and mirrors) and out into the surrounding environment. The light pulses reflect off of objects in the environment and return to the LiDAR system through its main lens and into a series of photodetectors. The system measures the time delay between the emitted pulse and detected pulse in order to determine the distance between the LiDAR device and the reflecting object. The laser diodes can be rapidly and repeatedly fired to collect distance information across a large surrounding environment. The system is able to combine the measured distances and orientations of each laser pulse in order to generate a three-dimensional

map of the surrounding environment. The three-dimensional map allows the system to make navigation decisions, such as whether to stop or turn to avoid an upcoming object.

26. In order for the LiDAR system to detect objects accurately, it is critical that the timing of the laser pulses is fast and reliable. Emitting the laser pulses quickly allows for more detection points over a given period of time, and therefore a more accurate map of the surrounding environment. Emitting the laser pulses at the right time ensures that the round-trip time from emission to detection accurately represents the distance to the detected object.

27. The inventions claimed in the '936 Patent relate to an improved firing circuit that quickly and reliably provides a voltage across a laser diode in a LiDAR system to generate the light pulses needed for detection. As discussed in more detail below, the firing circuit uses a single transistor to control the circuit's charge cycle and emission cycle. This allows the circuit to begin charging as soon as the laser diode stops emitting light. There is no lag between the end of the emission cycle and the beginning of the charge cycle. As a result, the circuit is recharged and ready to fire more quickly, and more light pulses can be emitted over a given time interval. More light pulses mean more data points, and therefore a more accurate mapping of the surrounding environment. This is critical for LiDAR systems used in autonomous vehicles. For the vehicle to be safe and reliable, it must accurately map its surrounding environment, and to that end, it must quickly and reliably generate the laser pulses used to collect data about the environment.

B. Specification

28. The specification of the '936 Patent describes various aspects of a LiDAR system used for autonomous vehicle navigation. '936 Patent at 1:16-46. FIG. 1 of the patent shows a functional block diagram of an autonomous vehicle 100 equipped with a LiDAR system. The vehicle includes the following components: a propulsion system 102 to provide powered motion to the vehicle; an engine 118; an energy source 119 to provide electrical or chemical energy to the engine; a transmission 120; and wheels 121. *Id*. at 6:16-7:4, Fig. 1. The vehicle 100 also includes a computer system 112 to control the vehicle while in an autonomous mode via control instructions to a control system 106; and a sensor system 104. *Id*. at 5:65-6:8.

29. The sensor system 104 includes one or more sensors configured to detect information about the environment surrounding the vehicle 100. *Id.* at 7:5-17. The sensors may include a Global Positioning System (GPS) 122 to estimate the geographic location of the vehicle; an inertial measurement unit (IMU) 124 that detects position and orientation changes of the vehicle; a RADAR system 126 that uses radio signals to sense objects within the local environment of the vehicle 100; and a LIDAR system 128 that uses lasers to detect objects in the environment. *Id.* at 7:5-39.

30. An example LiDAR system disclosed in the '936 Patent includes a light source (*e.g.*, one or more laser diodes), beam-steering optics (*e.g.*, mirrors and lenses), a light sensor (*e.g.*, photo detectors), and a controller (*e.g.*, a computer and associated electronics). *Id.* at 12:55-13:14. The laser diodes emit pulses of light toward the beam-steering optics, which direct the pulses of light across a scanning environment. *Id.* Objects in the scanning environment reflect the emitted pulses of light back to the LiDAR system, where they are detected by the photo detectors. *Id.* The controller can regulate the operation of the laser diodes to scan pulses of light across the scanning environment. *Id.* The controller can also be configured to estimate the position of objects that reflect the light pulses back to the LiDAR system. *Id.* For example, the controller can measure the time delay between emission of a pulse of light and reception of a reflected light signal and determine the distance to the reflective object based on the time of flight of a round trip. *Id.* The controller may also use the orientation of the beam-steering optics at the time the pulse of light is emitted to estimate a direction toward the reflective object. *Id.* The estimated direction and estimated distance can then be combined to generate a three-dimensional "point cloud" representing the distance of the reflective object relative to the LIDAR device. *Id.*

31. Figures 3B and 3C of the patent illustrate the detection of a car 310 and a tree 312, and the resulting point cloud that includes spatial data for the car 314 and tree 316:

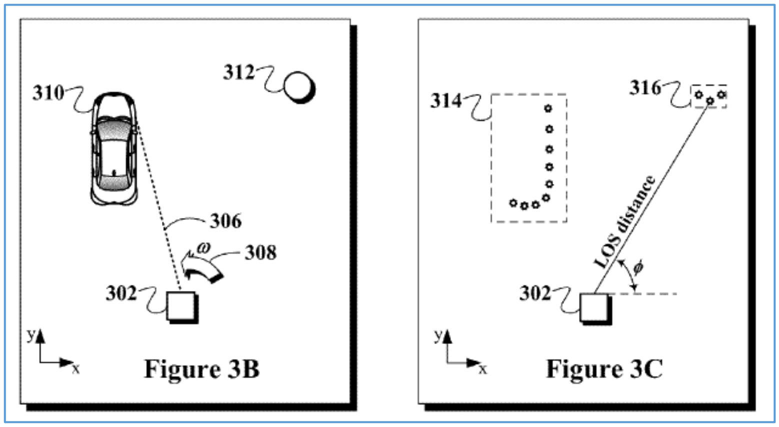


Figure 3B Figure 3C

Id. Figs. 3B and 3C; 13:50-1428.

32. Figures 4A and 4B depict an example of the LiDAR system scanning an environment by emitting laser pulses along beam paths 306a through 306d at equal intervals, along with an associated timing diagram representing the transmission and detection of the light pulses:

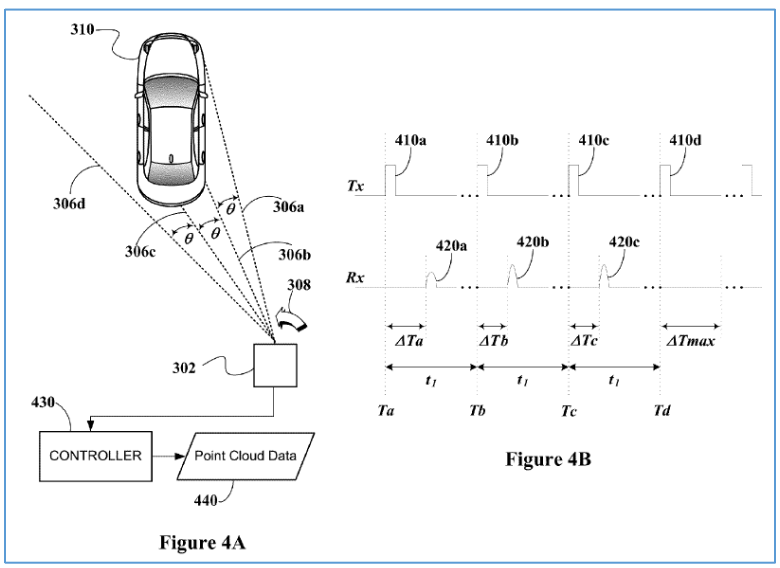


Figure 4A Figure 4B

Id. at Figs. 4A and 4B; 14:63-15:36.

33. The pulses 410a through 410d are fired at equal time intervals t_1. However, the detected signals 420a through 420d are received at different times, representing the different distances that the beam travels to and from the detected object. For example the time interval ΔTa is longer than the time interval ΔTb because the front of the car is a further distance away from the LiDAR system than the back of the car. The time interval ΔTmax represents the fact that laser pulse 410d travels along a beam path 306d that does not hit any reflective object.

34. The specification explains, "A light pulse with the desired temporal profile can be generated by applying a rapidly switched current to a laser diode (*e.g.*, a current source that rapidly transitions from near zero current to a current sufficient to cause the laser diode to emit light)." *Id.* at 17:26-40. The specification refers to the electronic circuits necessary to generate the current as "laser diode firing circuits." *Id.* Example circuits may switch from near zero current through the laser diode, to about 30 amperes of current, and back to near zero, in a span of about 1-2 nanoseconds. *Id.*

35. Figure 5A depicts an example laser diode firing circuit:

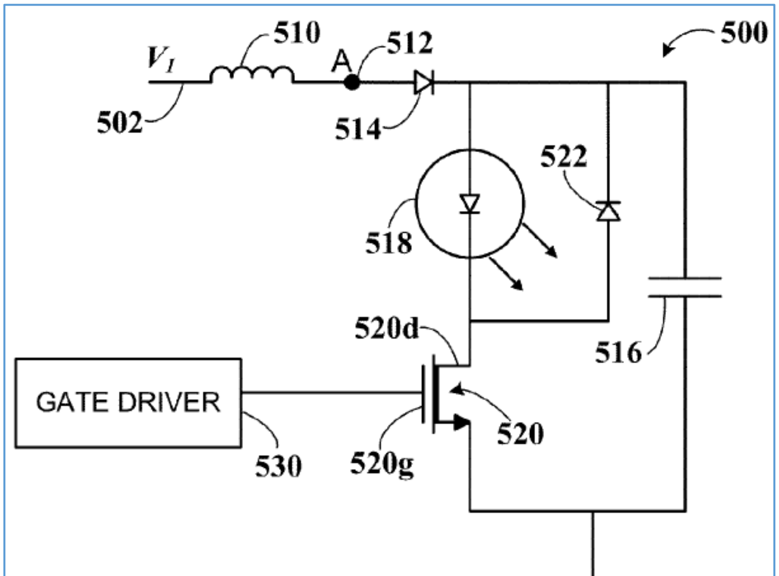


Figure 5A

36. The components of the circuit 500 include a voltage source 502, inductor 510, reference node A 512, diode 514, charge capacitor 516, laser diode 518, transistor 520, gate driver 530, and discharge diode 522. *Id.* at 17:47-63. The components work to provide a charging mode and an emission (or discharge) mode, shown in Figures 5C and 5D, respectively:

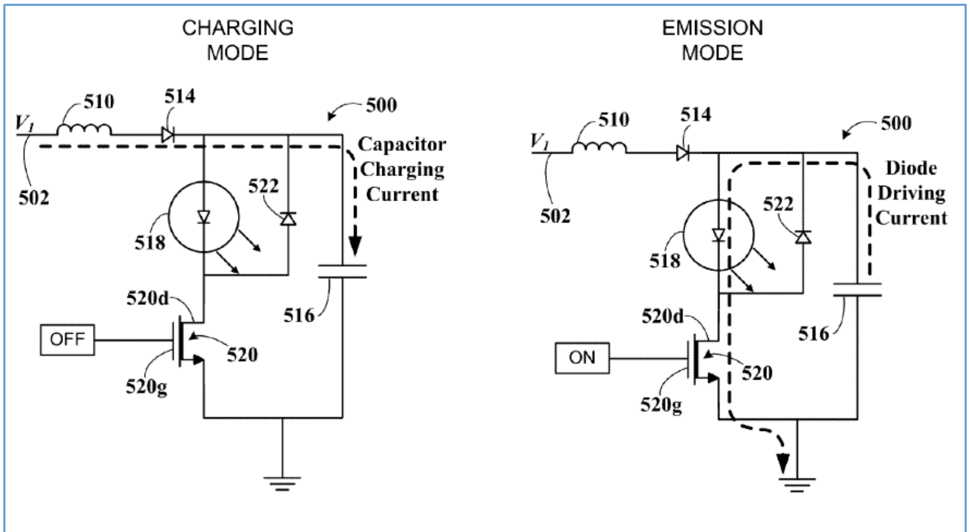


Figure 5C

Figure 5D

37. In charging mode, the voltage across the capacitor 516 starts out lower than the voltage at reference node A. *Id.* at 22:38-55. The transistor 520 is off, preventing current from flowing through the laser diode 518. *Id.* Instead, current flows from the voltage source 502, through the inductor 510, through the diode 514, and to the capacitor 516 allowing it to accumulate charge. *Id.* The specification explains that, following a discharge, the capacitor 516 can be recharged in approximately 500 nanoseconds. *Id.* In emission (or discharge) mode, the transistor 520 is turned on, allowing the capacitor to rapidly discharge through the laser diode 518 causing it to emit light. *Id.* at 22:54-67.

38. A significant benefit of the circuit shown in Figure 5A is that it uses a single transistor to both the charging and discharging operations. *Id.* at 25:21-32. Turning the single transistor on will cause the circuit to both emit a pulse of light by discharging the capacitor through the laser diode, and initiate a recharge cycle by lowering the voltage on the capacitor and thereby causing current to flow towards the capacitor. *Id.*

39. Figure 5B is a timing diagram that shows the state of various components during emission (or discharge) and charging of the firing circuit 500:

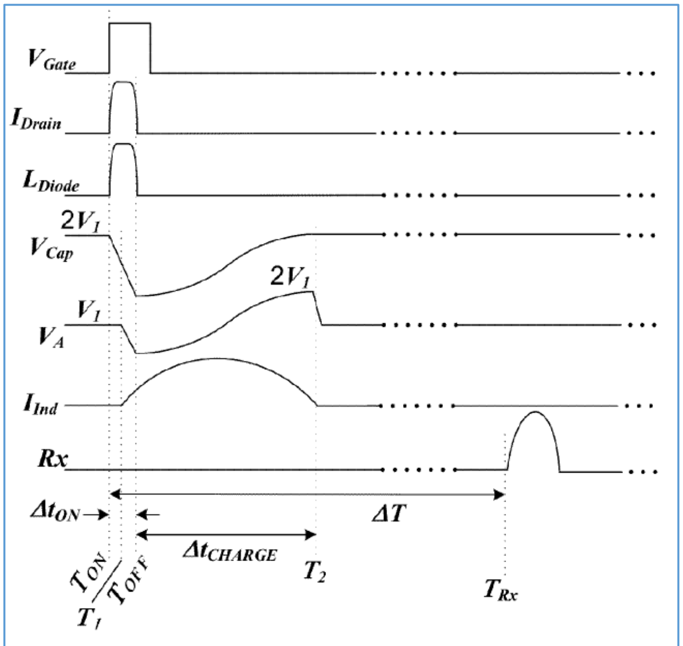


Figure 5B

40. The horizontal axis of the timing diagram defines five specific times: T_{ON}, T_1, T_{OFF}, T_2, and T_{RX}. *Id.* at 19:14-24. It also defines three specific time intervals: Δt_{ON}, Δt_{CHARGE}, and ΔT. *Id.* Time T_{ON} represents point at which the transistor 520 is turned on to discharge the capacitor 516 through the laser diode 518. *Id.* Time T_{OFF} represents the point at which the transistor 520 is turned off in order to stop current from flowing into the laser diode 518. *Id.* at 19:55-60. Time interval Δt_{ON} represents the interval between T_{ON} and T_{OFF} that it takes to discharge the capacitor through the laser diode in order to emit a pulse of light. *Id.* After the transistor is turned off at time T_{OFF}, the capacitor begins the process of recharging. *Id.* at 21:53-22:11. The capacitor recharges over the time interval Δt_{CHARGE} until time T_2. *Id.* Time interval ΔT represents the roundtrip time for the LiDAR system to generate and detect the pulse, between T_{ON} and T_{RX}. *Id.* at 22:13-22. Finally, time T_1 represents the point at which current begins flowing into the inductor 510 shortly after the transistor is turned on. *Id.* at 20:3-11.

41. The vertical axis of Figure 5B represents the value of different circuit components over time. Voltage V_{Gate} represents the voltage on the transistor 520. *Id.* at 19:14-24. Luminance L_{Diode} represents the light emission from the laser diode 518. *Id.* Voltage V_{Cap} represents the voltage

on the capacitor 516. *Id.* Voltage V_A represents the voltage at reference node A. *Id.* Current I_{Ind} represents the current through the inductor 510. *Id.*

42. At time T_{ON}, the voltage on V_{Gate} is applied to the gate of transistor 520 in order to turn it on. *Id.* at 19:25-40. The voltage V_{Cap} on the capacitor 516 decreases from its maximum value $2V_1$ to zero as the capacitor discharges through the laser diode 518. *Id.* The luminance L_{Diode} of the laser diode peaks as it emits a pulse of light. *Id.*

43. Shortly after the transistor 520 is turned on (but before it is turned off), the current I_{Ind} through the inductor 510 begins to increase at time T_1. *Id.* at 20:3-18. The current I_{Ind} through the inductor 510 results from the fact that the voltage VCap on the capacitor 516 has started to decrease. *Id.* One property of the inductor 510 is that it tries to resists changes in current flowing through it. *Id.* at 21:15-39. When the current I_{Ind} starts to increase at time T_1, a voltage is induced in the inductor to oppose the current change. *Id.* at 20:3-18. Initially, the increased voltage on the inductor causes the voltage at reference node A to decrease as shown in Figure 5B between time T_1 and T_{OFF}. *Id.* At time T_{OFF}, however, the transistor 520 is turned off and the current through the inductor moves through the charging path, including reference node A, diode 514, and capacitor 516. *Id.* at 20:19-25. As a result, the voltages V_{Cap} and V_A begin to increase. *Id.*

44. Time T_{OFF} marks the beginning of the charge cycle, during which the voltage V_{Cap} eventually increases to value $2V_1$. *Id.* The current from the inductor 510 may charge the capacitor 516 in a sinusoidal oscillatory fashion as shown in Figure 5B. *Id.* At one quarter of the oscillation period, the inductor current I_{Ind} reaches a maximum, and begins to decrease. *Id.* At that point, the stored energy of the circuit is divided equally between the inductor 510 and the capacitor 516. *Id.* Current continues to flow to the capacitor 516, until the mid-point of the oscillation cycle, at time T_2, at which point the current through the inductor 510 reaches zero and the capacitor 516 stores substantially all of the energy that had been divided between the inductor 510 and the capacitor 516. *Id.* When the energy on the capacitor 516 tried to transfer back to the inductor 510, the diode 514 becomes reverse biased to block the current flow. *Id.* As a result, the voltage V_{Cap} on the capacitor 516 remains at approximately the maximum value $2V_1$ as shown in Figure 5B.

45. The timing diagram in Figure 5B illustrates another benefit of the circuit shown in Figure 5A: the capacitor 516 is recharged immediately following a pulse emission. *Id*. at 21:53-22:11. The circuit uses a single transistor for both the charging and discharge cycles. *Id*. The specification explains the benefit of this design as follows: "If, for example, a recharging operation were to be initiated after some duration following a pulse emission (e.g., using a second transistor other than a transistor controlling current through a laser diode), the additional time would increase the lag time between emission of subsequent pulses and thus reduce the duty cycle of the firing circuit." *Id*. In order to shorten the duty cycle, "the firing circuit 500 is configured to immediately recharge the capacitor 516 upon emission of a pulse because the recharging operation is initiated in response to operation of the same transistor 520 that initiates emission (e.g., turning on the transistor 520 both causes a pulse to be emitted and, upon sufficient discharge from the capacitor 516, causes the diode 514 to become forward biased and current to begin flowing through the inductor 510 so as to initiate charging)."

C. Prosecution History

46. The application underlying the '936 Patent was filed on December 18, 2013. On March 2, 2016, the Patent Examiner allowed all of the pending claims. In his Reasons for Allowance, the Examiner explained cited U.S. Patent No. 9,185,762 ("Mark") as an example of a "typical laser driver circuit." The Examiner explained that Mark does not teach or suggest the configuration shown in Figure 5A of the '936 Patent. In addition to the Mark reference, the Examiner cited U.S. Patent Publication Nos. 2013/0314711, 2014/0312233, and 2014/0269799, but did not address these references specifically.

D. Asserted Claims

47. I understand that Waymo has asserted claims 1, 3, 5-7, 9, 11, 14, 16, 17, 19, and 20. Independent claim 17 and dependent claim 19 are reproduced below.

17. A light detection and ranging (LIDAR) device comprising:

a light source including:

a voltage source;

> an inductor coupled to the voltage source, wherein the inductor is configured to store energy in a magnetic field;
>
> a diode coupled to the voltage source via the inductor;
>
> a transistor configured to be turned on and turned off by a control signal;
>
> a light emitting element coupled to the transistor;
>
> a capacitor coupled to a charging path and a discharge path, wherein the charging path includes the inductor and the diode, and wherein the discharge path includes the transistor and the light emitting element;
>
> wherein, responsive to the transistor being turned off, the capacitor is configured to charge via the charging path such that a voltage across the capacitor increases from a lower voltage level to a higher voltage level and the inductor is configured to release energy stored in the magnetic field such that a current through the inductor decreases from a higher current level to a lower current level; and
>
> wherein, responsive to the transistor being turned on, the capacitor is configured to discharge through the discharge path such that the light emitting element emits a pulse of light and the voltage across the capacitor decreases from the higher voltage level to the lower voltage level and the inductor is configured to store energy in the magnetic field such that the current through the inductor increases from the lower current level to the higher current level;
>
> a light sensor configured to detect a reflected light signal comprising light from the emitted light pulse reflected by a reflective object; and
>
> a controller configured to determine a distance to the reflective object based on the reflected light signal.
>
> * * * * *
>
> 19. The LIDAR device of claim 17, wherein the capacitor is charged immediately following emission of a pulse of light from the light emitting element.

’936 Patent at claims 17 and 19.

E. Level of Ordinary Skill in the Art

48. The ’936 Patent was filed on December 18, 2013, and claims priority to a provisional application filed September 30, 2013. In my opinion, a person of ordinary skill in the art at the time of the invention would have had an undergraduate degree in electrical engineering, with at least two years of experience designing electrical circuits for light-emitting semiconductor devices such as light-emitting diodes or laser diodes. I met and exceeded these qualifications at the time of the

invention. My opinion on the level of ordinary skill in the art would not change if the time of the invention were taken as the filing date of the '936 patent, the filing date of the underlying provisional application, or a year before that date.

VI. ANALYSIS AND OPINIONS

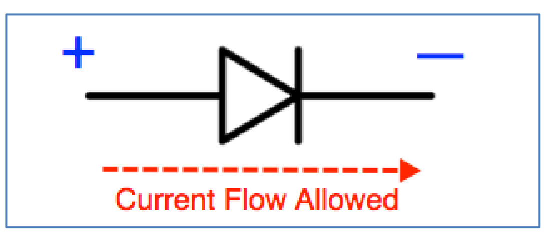
49. I understand that the parties dispute three terms from the asserted claims of the '936 Patent: "diode," "charging path," and "wherein the capacitor is charged immediately following emission of a pulse of light from the light emitting element." In the following sections, I offer opinions concerning the construction of the first and third terms: "diode" and "wherein the capacitor is charged immediately following emission of a pulse of light from the light emitting element."

A. "diode"

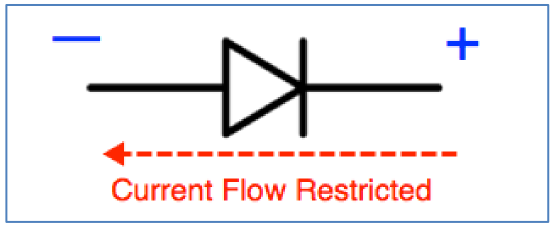
Waymo's Proposed Construction	Defendants' Proposed Construction
Plain meaning	"a two terminal semiconductor device with an anode and a cathode that allows the flow of current in one direction only"

50. The term "diode" appears in each of the asserted independent claims. Independent claim 1, for example, recites "a diode coupled to the voltage source via the inductor … a capacitor coupled to a charging path and a discharge path, wherein the charging path includes the inductor and the diode." '936 Patent, claim 1.

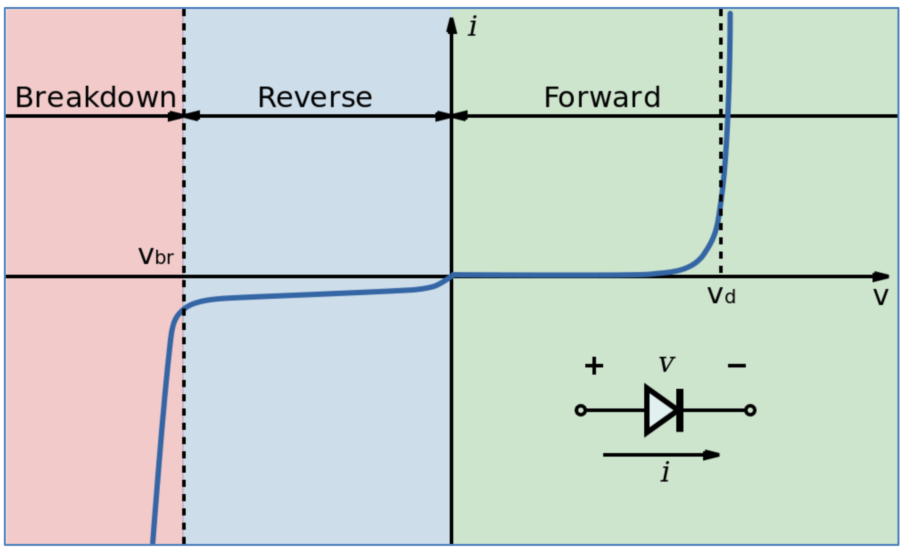
51. A diode is a well-known electrical device and a common element in electronic circuits. A diode has two terminals and allows current to flow more easily in one direction than the other depending on the voltages applied across the terminals. A diode also has a well-known operation. When a positive voltage is applied across the terminals, the diode becomes "forward biased" and allows current to flow in the first direction, as illustrated below:



52. When a negative voltage is applied across the terminals, the diode becomes "reverse biased" and restricts current flow in the opposite direction, as illustrated below:



53. The operation of a diode is depicted using current-voltage, or I-V curves. The curve depicts the flow of current through the diode as a function of the voltage applied across the diode terminals.



54. The positive voltages depicted in green on the right-hand side of the vertical axis generally represent the forward bias state of the diode. In this part of the diagram, the current through the diode increases in the "forward" direction as a function of positive voltage. The value of Vd is known as the "threshold" voltage and represents the point at which the diode becomes sufficiently forward-biased to allow free current flow.

55. The negative voltages depicted on the left-hand side of the vertical axis in blue generally represent the reverse bias state of the diode. In this part of the diagram, the current through the diode increases in the "reverse" direction as a function of negative voltage. The current is low and the increase is gradual up to a point known as "breakdown" shown in red, where the voltage overcomes the innate resistance of the diode and allows free current flow in the reverse direction.

Prior to the breakdown region, the current flow is known as "leakage." Note that while both the positive and negative current flows are often generally characterized as "on" or "off" the current in either direction is a function of the voltage applied and changes continually to correspond to the voltage applied. The current through the diode is actually only zero when the voltage across the diode is zero.

56. In my opinion, the specification of the '936 Patent uses the term "diode" consistent with its accepted meaning. The specification explains that the diode forms part of a charging path for the firing circuit. '936 Patent at e.g. 1:58-60, Fig. 5B. During the charge cycle, the diode becomes forward biased to allow current flow and charge the capacitor. *Id*. at 1:62-63, 5:9-12, 18:35-37 ("The diode 514 is forward biased (and thus allows the capacitor 516 to charge) when the voltage at node A 512 is greater than the voltage on the capacitor 516."). When the voltage on the capacitor exceeds the voltage at node A, the diode may become reverse biased to hold charge on the capacitor. *Id*. at 5:12-16 ("The diode is also configured to be reverse biased when the voltage across the capacitor exceeds the voltage applied to the diode by the inductor (to thereby prevent the capacitor from discharging)."). These descriptions track the normal operation of a diode as discussed above. They do not alter or modify the operation of a diode in any way, or indicate a specialized meaning of the term "diode."

57. In my opinion, Defendants' proposed construction for the term "diode" is inconsistent with the understood meaning of the term. Defendants' proposed construction is "A two terminal semiconductor device with an anode and a cathode that allows the flow of current in one direction only." The construction appears to be based on a definition from the McGraw Hill Illustrated Dictionary of Electronics (2001), which states "**diode** A two-element device containing an anode and a cathode, and providing unidirectional conduction." *See* Jaffe Decl., Ex. 1. In my opinion, this definition and Defendants' proposed construction are not accurate because they specify current flow "in one direction only" or "unidirectional conduction."

58. As discussed above, a diode generally allows current flow in the forward direction under forward bias conditions, and generally restricts current flow in the reverse direction under reverse bias conditions. However, a person of ordinary skill in the art would understand that current

flow in the reverse direction is not completely blocked as suggested by Defendants' construction. Some amount of current—referred to typically as "leakage" current—will flow in the reverse direction under reverse bias conditions, and current will flow freely in the reverse direction under breakdown. Defendants' proposed construction excludes both of these principles of operation, and therefore is not accurate from a technical standpoint.

59. In my opinion, a more accurate definition of a diode is provided in the Modern Dictionary of Electronics (1999), cited in the Defendants' Patent Local Rule 4-2 identification of extrinsic evidence. That dictionary includes a definition that recites, "A two-terminal electronic device that will conduct electricity much more easily in one direction than in the other." Jaffe Decl., Ex. 1. A similar definition is found in the Authoritative Dictionary of IEEE Standard Terms (2000), which recites "A two-electrode electron tube containing and anode and a cathode" and "A semiconducting device used to permit current flow in one direction and to inhibit current flow in the other direction." *Id*., Ex. 2.

60. The descriptions of a diode as conducting electricity much more easily in one direction than in the other, and permitting current flow in one direction while inhibiting current flow in the other direction, accurately reflect the understood operation of a diode and in particular the concepts of leakage current and breakdown.

61. The dictionary definitions also reflect the fact that diodes are not limited to "semiconductor" devices that include an anode and cathode as required under Defendants' proposed construction. For example, a diode can be an electron tube, which is not a semiconductor device.

62. The dictionary definitions discussed above demonstrate that there are multiple definitions of the term "diode," and in my opinion, Defendants' proposal is the least accurate among them. Because a diode is a well-known circuit element with a well-understood operation (much like a capacitor or inductor), it is my opinion that the term does not require additional definition in order to be understood by persons of skill in the art or explained to a layperson. If, however, the Court determines that a definition would be helpful, it is my opinion that the definition should account for the fact that some current will flow through a diode in the reverse direction. An appropriate

definition would be "A two-terminal electronic device that will conduct electricity much more easily in one direction than in the other."

B. "wherein the capacitor is charged immediately following emission of a pulse of light from the light emitting element"

Waymo's Proposed Construction	Defendants' Proposed Construction
Plain meaning	Indefinite

63. The phrase "wherein the capacitor is charged immediately following emission of a pulse of light from the light emitting element" appears in asserted dependent claims 3, 11, and 19. I understand that Defendants have not yet provided briefing on this term, but I understand they may argue the term "immediately" renders the claims indefinite. As discussed above, counsel has informed me about the legal standards for the definiteness requirement. I understand that the analysis is performed in the context of the patent specification and prosecution history, from the perspective of a person having ordinary skill in the art. Under these standards, it is my opinion that the claim language provides reasonable certainty concerning the scope and meaning of the phrase.

64. The phrase "wherein the capacitor is charged immediately following emission of a pulse of light from the light emitting element" refers to the transition between a discharge cycle and charge cycle of the firing circuit. '936 Patent at 21:53-22:11. In my opinion, the specification provides a detailed and objective description of this transition and what it means for the capacitor to charge "immediately" following emission of a pulse of light.

65. The specification uses timing diagrams to illustrate the transition between the emission of a pulse of light and the charging of the capacitor. *Id*. at 19:14-24, Fig. 5B. These timing diagrams are known in the art and would be familiar to a person of ordinary skill. The timing diagrams are shown in Figure 5B, which I have highlighted below:

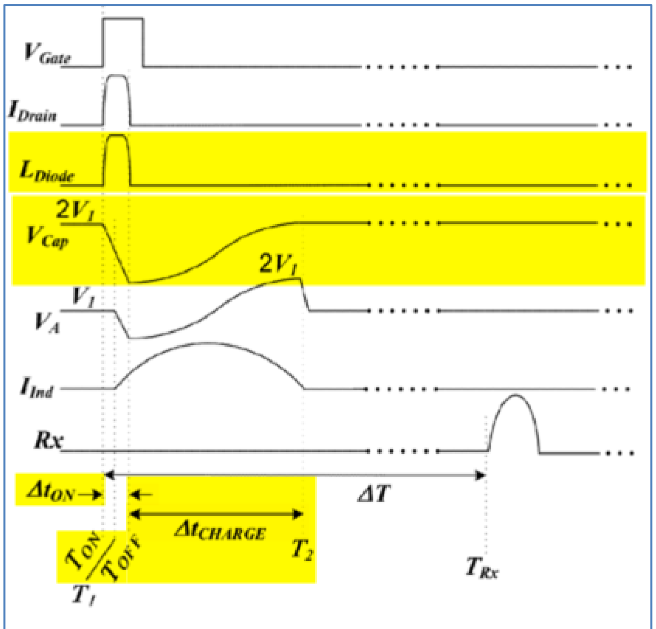


Figure 5B

Id. at Fig. 5B.

66. The diagram labeled L_{Diode} shows the emission pulse of the laser diode (*i.e.*, the light emitting element) as a function of time. *Id.* at 19:16-18. The bottom portion of the diagram shows the laser diode beginning to emit light at time T_{ON} and ceasing to emit light at time T_{OFF}. *Id.* at 19:33-40, 20:21-22. The diagram labeled V_{Cap} refers to the voltage on the capacitor. *Id.* at 19:16-18. As shown, the voltage decreases between time T_{ON} and time T_{OFF}, corresponding to the emission of light from the laser diode. *Id.* at 19:33-49, 20:21-25. At time T_{OFF}, the voltage on the capacitor increases and it begins to charge. *Id.* The charge cycle lasts between time T_{OFF} and time T_2, represented as Δt_{CHARGE} at the bottom of the timing diagram. *Id.*

67. Reading these timing diagrams, a person of ordinary skill in the art would understand that the capacitor charges "immediately" following the emission of light because its voltage begins to increase as the emission of light from the laser diode ceases. A person of ordinary skill in the art could create the same type of diagrams for a given firing circuit and use them to determine objectively whether the capacitor in the firing circuit is charged immediately following emission of a pulse of light from the laser diodes.

68. The specification also explains that the immediate charging of the capacitor is a product of the single-transistor operation of the firing circuit. The specification states that "In some

examples, the firing circuit 500 is configured to immediately recharge the capacitor 516 upon emission of a pulse because the recharging operation is initiated in response to operation of the same transistor 520 that initiates emission (e.g., turning on the transistor 520 both causes a pulse to be emitted and, upon sufficient discharge from the capacitor 516, causes the diode 514 to become forward biased and current to begin flowing through the inductor 510 so as to initiate charging)." *Id*. at 22:3-11. The operation of the single transistor is discussed with respect to the timing diagrams of Figure 5B. The transistor turns ON at time T_{ON}, which results in current discharging through the laser diode to emit a pulse of light. *Id*. at 19:33-40 ("At the turn on time T_{ON}, an initiating signal is applied to the transistor 520 from the gate driver 530. … The transistor 520 turns on and the drain current I_{Drain} transitions from a current near zero to a current sufficient to drive the laser diode 518. The laser diode 518 emits a pulse of light, as indicated by the luminosity L_{Diode}."). The transistor turns off at time T_{OFF}, which results in current ceasing to flow through the laser diode, and recharging of the capacitor. *Id*. at 20:21-22 ("At time T_{OFF}, current ceases flowing through the laser diode 518…"); *id*. at 21:55-58 ("As shown in FIG. 5B, a capacitor recharging interval Δt_{CHARGE} begins at the transistor turn off time T_{OFF}…").

69. The specification also distinguishes the single-transistor design of the '936 Patent from firing circuits that use two transistors—one to control the firing of the laser diode and another to control the charging of the capacitor. *Id*. at 21:60-22:11. The two-transistor embodiments result in a lag between the laser diode firing and the capacitor charging and thus do not meet the "immediately" requirement of the asserted claims. *Id*. ("If, for example, a recharging operation were to be initiated after some duration following a pulse emission (e.g., using a second transistor other than a transistor controlling current through a laser diode), the additional time would increase the lag time between emission of subsequent pulses and thus reduce the duty cycle of the firing circuit."). In my opinion, these disclosures would provide additional guidance to a person of ordinary skill in the art concerning the immediate charging of the capacitor following the emission of a pulse of light.

70. Accordingly, it is my opinion that the specification provides reasonable certainty concerning the scope and meaning of the phrase "wherein the capacitor is charged immediately following emission of a pulse of light from the light emitting element."

VII. CONCLUSION

71. I declare under penalty of perjury that to the best of my knowledge the foregoing is true and correct.

Dated: August 7, 2017

Andrew Wolfe, Ph.D.
Washington, DC

APPENDIX A

Andrew Wolfe Ph.D.

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Education:

Ph.D. in Computer Engineering, Carnegie Mellon University, 1992
Visiting Graduate Student, Center for Reliable Computing, Stanford University, 1988-1989
M.S. in Electrical and Computer Engineering, Carnegie Mellon University, 1987
B.S.E.E. in Electrical Engineering and Computer Science, The Johns Hopkins University, 1985

Recent Employment:

Consultant, [October 2002-present]
Wolfe Consulting

Consultant on processor technology, computer systems, consumer electronics, software, design tools, and intellectual property issues. Testifying and consulting expert for IP and other technology-related litigation matters.

Sample clients include:

AMD	Nvidia	Samsung
IBM	Motorola	HTC
SMIC	AMKOR	Huawei
Dell	Honeywell	Western Digital
Nintendo	Kingston	Sonos
Moneygram	Arraycomm	Insilica
Synaptics	Activision	Sawstop
Mysticom	P.A.R.C.	Quester Ventures

Lecturer, [September 2013-present]
Santa Clara University

Teaching graduate and undergraduate courses on computer architecture, electronics and embedded computing, and mechatronics.

Chief Technical Officer, [1999-2002]; Sr. VP of Business Development, [2001-2002]; VP, Systems Integration, S3 Fellow , [1998 – 1999]; Director of Technology, S3 Fellow , [1997 - 1998]
SONIC|blue, Inc, Santa Clara, CA (formerly S3 Inc.)

Strategic Business Development:
Developed and implemented strategy to reposition S3 from PC graphics into the leading networked consumer electronics company.

- Acquired Diamond Multimedia and coordinated integration of communications, Rio digital music, and workstation graphics divisions into S3.
- Identified and negotiated acquisitions to grow digital media businesses including Empeg, ReplayTV, and Sensory Science.
- Identified and negotiated strategic investments including Comsilica, Intellon, KBGear Interactive, Entridia, DataPlay and others.
- Developed strategy for integrated graphics/core-logic products and established a joint venture with Via Technologies to design and market these products.
- Negotiated divestiture of graphics chip business to Via and the workstation graphics division to ATI.

Product Planning and Development:
- Drove roadmap development within SONICblue product divisions.
- Managed Business Development for all product lines.
- Led New Product Development and Corporate Vision processes.
- Acting co-General Manager of Rio digital music business in 2nd half of 2001. Responsible for all areas of product development, business development, and cost management.
- Managed development of the Savage/MX and Savage/IX mobile 3D graphics accelerators and Savage/NB system logic products.

Public Relations, Public Policy and Investor Relations:
- Present company products and strategy at industry events such as CES, Comdex, and Microprocessor Forum.
- Discuss new products and initiatives with the press.
- Promote issues of interest to SONICblue to industry groups and in Washington.
- Brief analysts, and investors on company progress. Participate in quarterly conference calls.

IP Management and Licensing:
- Negotiated and managed partnership agreements including a critical cross-licensing agreement with Intel.
- Renegotiated technology-licensing agreements with IBM for workstation graphics products.
- Evaluated outside technology opportunities, managed video research and development, and managed corporate IP strategy with legal staff including patent filings, cross licensing, and litigation.

Consulting Professor , [1999-2002]
Stanford University, Stanford, CA

Teaching computer architecture and microprocessor design.

Assistant Professor [1991 - 1997]
Princeton University, Princeton, NJ

Teaching and research in the Electrical Engineering department. Research in embedded computing systems, multimedia, video signal processors, compiler optimization, and high performance computer architecture. Principal investigator or project manager for ~$6M in funded research.

Visiting Assistant Professor , [1992]
Carnegie Mellon University, Pittsburgh, PA

Research and preparation of teaching materials on advanced microprocessor designs including new superscalar and superpipelined processor architectures.

Founder and Vice President and Consultant, [1989 - 1995]
The Graphics Technology Company, Inc., Austin, TX

Founded company to develop touch-sensitive components and systems for the first generation of PDA devices and interactive public systems. Obtained financing from Gunze Corp., Osaka, Japan. Company is now part of 3M.

Senior Electrical Engineer, [1989]
ESL - TRW, Advanced Technology Division, Sunnyvale, CA

Designed the architecture for an Intel i860-based multiple-processor digital signal processing system for advanced military applications. Designed several FPGA interface chips for VME-bus systems.

Design Consultant, [1986 -1987]
Carroll Touch Division, AMP Inc., Round Rock, TX

Developed several new technologies for touch-screen systems. Designed the first ASIC produced for AMP, a mixed-signal interface chip for controlling touch-screen sensors. Developed the system electronics, system firmware, and customer utility software for numerous products including those based on the new ASIC.

Senior Design Engineer, [1983 -1985]
Touch Technology Inc., Annapolis, MD

Advisory Boards:

Director, Turtle Beach Corporation (NASDAQ:HEAR) (formerly Parametric Sound Corporation), KBGear Interactive, Inc., Comsilica, Inc., Rioport.com, various S3 subsidiaries.

Technical Advisory Boards, Ageia, Inc., Intellon, Inc., Comsilica, Inc., Entridia, Inc., Siroyan, Ltd., BOPS, Inc, Quester Venture Funds

Carnegie Mellon University Silicon Valley Advisory Board; Johns Hopkins University Tech Transfer Advisory Board

Awards:

Micro Test-of-Time Award (in recognition of one of the ten most influential papers of the first 25 years of the symposium), 2014
Business 2.0 "20 Young Executives You Need to Know", 2002
Walter C. Johnson Prize for Teaching Excellence, 1997.
Princeton University Engineering Council Excellence in Teaching Award, Spring 1996
AT&T/Lucent Foundation Research Award, 1996.
Walter C. Johnson Prize for Teaching Excellence, 1995
IEEE Certificate of Appreciation, 1995, 2001.
AT&T Foundation Research Award, 1993.
Semiconductor Research Corporation Fellow, 1986 - 1991.
Burroughs Corporation Fellowship in Engineering, 1985 - 1986.

Professional Activities:

Program Chair: Micro-24, 1991, Hot Chips 13, 2001.

General Chair: Micro-26, 1993, Micro-33, 2000.

Associate Editor: IEEE Computer Architecture Letters; ACM Transactions in Embedded Computing Systems

Speaker at CES, WinHec, Comdex, Intel Dev. Forum, Digital Media Summit, Microprocessor Forum, etc.

Keynote speaker at Micro-34, ICME 2002

IEEE B. Ramakrishna Rau Award committee – 2012-2016

IEEE Computer Society Awards Committee – 2015

CES Awards Judge - 2016

Over 50 refereed publications.

Publications since January 2006:

Wolfe, A., "Retrospective on Code Compression and a Fresh Approach to Embedded Systems", IEEE MICRO, July/Aug. 2016, Invited paper.

Patents:

U.S. Pat. 5,041,701 – *Edge Linearization Device for a Contact Input System*, Aug. 20, 1991.
U.S. Pat. 5,438,168 – *Touch Panel*, Aug. 1, 1995.
U.S. Pat. 5,736,688 – *Curvilinear Linearization Device for Touch Systems*, Apr. 7, 1998.
U.S. Pat. 6,037,930 – *Multimodal touch sensitive peripheral device*, March 14, 2000.
U.S. Pat. 6,408,421 – *High-speed asynchronous decoder circuit for variable-length coded data*, June 18, 2002.
U.S. Pat. 6,865,668 – *Variable-length, high-speed, asynchronous decoder circuit*, March 8, 2005
U.S. Pat. 7,079,133 – *Superscalar 3D Graphics Engine*, July 18, 2006
EP 1 661 131 B1 – *PORTABLE ENTERTAINMENT APPARATUS*, Jan. 21, 2009
U.S. Pat. 7,555,006 – *Method and system for adaptive transcoding and transrating in a video network*, June 30, 2009
U.S. Pat. 7,996,595 – *Interrupt Arbitration for Multiprocessors*, Aug. 9, 2011
EP 2 241 979 B1 – *Interrupt Arbitration for Multiprocessors*, Oct. 10, 2011
GB201121568D0 – *Mapping Of Computer Threads onto Heterogeneous Resources*, Jan. 25, 2012
U.S. Pat. 8,131,970 – *Compiler Based Cache Allocation*, March 6, 2012
U.S. Pat. 8,180,963 – *Hierarchical read-combining local memories*, May 15, 2012
U.S. Pat. 8,193,941 – *Snoring Treatment*, June 5, 2012
U.S. Pat. 8,203,541 – *OLED display and sensor*, June 19, 2012
U.S. Pat. 8,243,045 – *Touch-sensitive display device and method*, August 14, 2012
U.S. Pat. 8,244,982 – *Allocating processor cores with cache memory associativity*, August 14, 2012
U.S. Pat. 8,260,996 – *Interrupt Optimization for Multiprocessors*, Sept. 4, 2012
101185761 (KR) – *Noise Cancellation for Phone Conversation,* Sept. 19, 2012
101200740 (KR) – *OLED display and sensor*, November 7, 2012
101200741 (KR) – T*ouch-sensitive display device and method*, November 7, 2012
U.S. Pat. 8,321,614 – *Dynamic scheduling interrupt controller for multiprocessors*, Nov. 27, 2012
U.S. Pat. 8,352,679 – *Selectively securing data and/or erasing secure data caches responsive to security compromising conditions*, Jan. 8, 2013
U.S. Pat. 8,355,541 – *Texture Sensing*, Jan. 15, 2013
U.S. Pat. 8,370,307 – *Cloud Data Backup Storage Manager*, Feb. 5, 2013
U.S. Pat. 8,398,451 – *Tactile Input Interaction*, March. 19, 2013
JP 5241032 B2 – *Routing Across Multicore Network Using Real World or Modeled Data*, April 13, 2013
ZL201010124820.3 – *Interrupt Optimization for Multiprocessors,* April 17, 2013
U.S. Pat. 8,428,438 – *Apparatus for Viewing Television with Pause Capability*, April 23, 2013
JP 5266197 B2 – *Data Centers Task Mapping,* May 10, 2013
U.S. Pat. 8,508,498 – *Direction and Force Sensing Input Device*, August 13, 2013
U.S. Pat. 8,547,457 – *Camera Flash Mitigation*, October 1, 2013
U.S. Pat. 8,549,339 – *Processor core communication in multi-core processor*, October 1, 2013
101319048 (KR) – *Camera Flash Mitigation*, October 10, 2013
U.S. Pat. 8,628,478 – *Microphone for remote health sensing*, January 14, 2014
101362017 (KR) – *Thread Shift: Allocating Threads to Cores*, Feb. 5, 2014
101361928 (KR) – *Cache Prefill on Thread Migration*, Feb. 5, 2014
101361945 (KR) – *Mapping Of Computer Threads onto Heterogeneous Resources*, Feb. 5, 2014
JP 5484580 B2 – *Task Scheduling Based on Financial Impact,* Feb. 28, 2014
JP 5487306 B2 – *Cache Prefill on Thread Migration*, Feb. 28, 2014
101372623 (KR) – *Power Management for Processor*, March. 4, 2014
101373925 (KR) – *Allocating Processor Cores with Cache Memory Associativity*, March 6, 2014
U.S. Pat. 8,676,668 – *Method for the determination of a time, location, and quantity of goods to be made available based on mapped population activity*, March 18, 2014
U.S. Pat. 8,687,533 – *Energy Reservation in Power Limited Networks*, April 1, 2014
101388735 (KR) – *Routing Across Multicore Networks Using Real World or Modeled Data*, April 17, 2014
JP 5487307 B2 – *Mapping Of Computer Threads onto Heterogeneous Resources*, May. 7, 2014
U.S. Pat. 8,725,697 – *Cloud Data Backup Storage*, May 13, 2014
U.S. Pat. 8,726,043 – *Securing Backing Storage Data Passed Through a Network*, May 13, 2014
ZL201010124826.0 – *Dynamic scheduling interrupt controller for multiprocessors*, May 14, 2014
JP 5547820 B2 – *Processor core communication in multi-core processor*, May 23, 2014

U.S. Pat. 8,738,949	–	*Power Management for Processor*, May 27, 2014
U.S. Pat. 8,751,854	–	*Processor Core Clock Rate Selection*, June 10, 2014
JP 5559891 B2	–	*Thermal Management in Multi-Core Processor*, June 13, 2014
101414033 (KR)	–	*Dynamic Computation Allocation*, June 25, 2014
JP 5571184 B2	–	*Dynamic Computation Allocation*, July 4, 2014
101426341 (KR)	–	*Processor core communication in multi-core processor*, May 23, 2014
U.S. Pat. 8,799,671	–	*Techniques for Detecting Encrypted Data*, Aug 5, 2014
101433485 (KR)	–	*Task Scheduling Based on Financial Impact,* Aug. 18, 2014
U.S. Pat. 8,824,666	–	*Noise Cancellation for Phone Conversation,* Sept. 2, 2014
U.S. Pat. 8,836,516	–	*Snoring Treatment*, Sept. 16, 2014
U.S. Pat. 8,838,370	–	*Traffic flow model to provide traffic flow information*, Sept. 16, 2014
U.S. Pat. 8,838,797	–	*Dynamic Computation Allocation*, Sept. 16, 2014
U.S. Pat. 8,854,379	–	*Routing Across Multicore Networks Using Real World or Modeled Data*, Oct. 7, 2014
JP 5615361 B2	–	*Thread Shift: Allocating Threads to Cores*, Oct. 15, 2014
U.S. Pat. 8,866,621	–	*Sudden infant death prevention clothing*, Oct. 21, 2014
U.S. Pat. 8,881,157	–	*Allocating threads to cores based on threads falling behind threads*, Nov. 4, 2014
U.S. Pat. 8,882,677	–	*Microphone for remote health sensing*, Nov. 11, 2014
U.S. Pat. 8,924,743	–	*Securing Data Cache through Encryption*, December 30, 2014
U.S. Pat. 8,994,857	–	*Camera Flash Mitigation*, March 31, 2015
JP 5699140 B2	–	*Camera Flash Mitigation*, April 8, 2015
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CN102483703B	–	*Mapping Of Computer Threads onto Heterogeneous Resources*, Oct. 14, 2015
U.S. Pat. 9,178,694	–	*Securing Backing Storage Data Passed Through a Network*, November 3, 2015
U.S. Pat. 9,189,282	–	*Thread-to-core mapping based on thread deadline, thread demand, and hardware characteristics data collected by a performance counter*, November 17, 2015
U.S. Pat. 9,189,448	–	*Routing image data across on-chip networks*, November 17, 2015
U.S. Pat. 9,208,093	–	*Allocation of memory space to individual processor cores*, December 8, 2015
U.S. Pat. 9,239,994	–	*Data Centers Task Mapping,* January 19, 2016
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U.S. Pat. 9,519,305	–	*Processor Core Clock Rate Selection*, December 13, 2016
U.S. Pat. 9,569,270	–	*Mapping thread phases onto heterogeneous cores based on execution characteristics and cache line eviction count*, February 14, 2017